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The Effects of Scie-Quest Gamification on the Computational Skills, Engagement and Motivation of Senior High School Students

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Abstract— This study examined the effects of Scie-Quest Gamification on the computational skills, engagement, and motivation of Grade 12 STEM students in General Physics II. It specifically aimed to determine students' pretest and posttest performance; describe their level of engagement and motivation; assess the perceived effectiveness of gamification in terms of concentration and focus, goal clarity, feedback quality, and challenge level; and test for significant differences between pretest and posttest scores. A pre-experimental one-group pretest-posttest design was utilized involving 63 Grade 12 Science, Technology, Engineering & Mathematics (STEM) students from Atimonan National Comprehensive High School. The Scie-Quest Gamification intervention was implemented over four weeks during lessons on electromagnetic waves and optics. Data were gathered using a validated General Physics Achievement Test and adapted observation questionnaires. Descriptive statistics were used to analyze engagement and perceived effectiveness variables, while a paired-samples t-test was used to determine differences in computational performance. Findings showed that students' computational performance improved from moderate in the pretest to high in the posttest after the intervention. Results further indicated that students demonstrated high levels of engagement and motivation and had positive perceptions of gamification regarding concentration, goal clarity, feedback quality, and challenge level. A significant difference was found between pretest and posttest scores, confirming that Scie-Quest Gamification is an effective instructional approach for improving the computational performance of senior high school students in physics.

Keywords— gamification, computational skills, Physics education, Scie-Quest.

I. INTRODUCTION

Educational technology has transformed the way students learn complex scientific concepts, particularly in physics, where abstract ideas and mathematical applications often challenge senior high school learners (Papadakis, Kalogiannakis, & Zaranis, 2025; Richter & Kickmeier-Rust, 2025). In the Philippines, traditional lecture-based instruction remains dominant despite students continuing to perform below international standards in science assessments such as TIMSS and PISA (Okoye, Nwuba, & Nwoye, 2024). Under the K–12 Curriculum, Grade 12 students are expected to master competencies related to electromagnetic waves and light, including reflection, refraction, total internal reflection, and optical computations using Snell's Law. However, many students struggle with these topics because of their abstract nature and mathematical complexity (Reyes & Santos, 2024; Sappaile, 2024).

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These challenges are further compounded by persistent weaknesses in science achievement reflected in international assessments. In the PISA 2022 results, the Philippines ranked third from the bottom in science with a mean score of 356, remaining significantly below the OECD average and demonstrating ongoing difficulties with applying scientific knowledge to real-world situations and problem-solving tasks (OECD, 2023). Global education monitoring reports have further documented that educational systems in developing countries, including the Philippines, continue to experience deficiencies in fundamental science and mathematics competencies due to limited access to quality instructional resources and the underutilization of student-centered pedagogical approaches (World Bank, 2022; UNESCO, 2023). These findings highlight the urgent need for schools to adopt innovative teaching methods, including gamification and technology-based learning tools, to improve students' understanding of physics concepts and strengthen their mathematical competencies.

Gamification has emerged as an innovative instructional approach that integrates game elements to improve student motivation, engagement, and academic performance (Dichev & Dicheva, 2017). Studies have shown that gamified physics instruction can enhance learning through simulations, feedback systems, and collaborative challenges (Katanosaka et al., 2024). Although previous studies mainly focused on motivation and conceptual understanding, limited research has examined the effectiveness of gamification in improving computational performance and problem-solving skills in optics among Filipino senior high school students (Reyes & Santos, 2024; Sailer & Homner, 2020).

II. OBJECTIVES OF THE STUDY

This study investigated the effects of Scie-Quest Gamification on the computational skills, engagement, and motivation of Grade 12 STEM students in General Physics II at Atimonan National Comprehensive High School during the second semester of the 2025–2026 academic year. Specifically, the study determined the respondents' pretest and posttest performance in computational skills, assessed their level of engagement and motivation, and examined their perceived effectiveness of Scie-Quest Gamification in terms of concentration and focus, goal clarity, feedback quality, and challenge level. Furthermore, the study tested whether there was a significant difference between the respondents' pretest and posttest performance after exposure to the gamified learning platform. The findings may contribute to the development of innovative and technology-based teaching strategies that support physics education in the Philippine senior high school context.

III. METHODOLOGY

This study employed a pre-experimental one-group pretest-posttest design to determine the effects of Scie-Quest Gamification on the computational skills, engagement, and motivation of Grade 12 STEM students in General Physics II. The research followed a three-phase procedure: a pretest, a four-week gamification intervention, and a posttest. The intervention covered topics in Electromagnetic Waves and Light, specifically Snell's Law, total internal reflection, dispersion, and optical problem-solving.

The participants were 63 Grade 12 STEM students drawn from two intact sections at Atimonan National Comprehensive High School during the second semester of the 2025–2026 academic year, selected through

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convenience sampling. Inclusion criteria required participants to have access to devices capable of running the Scie-Quest platform and to maintain at least 80% attendance throughout the intervention period.

Prior to data collection, the researcher secured ethical clearance from the relevant institutional body and obtained informed consent from the participants and their parents or guardians. Participation was entirely voluntary, and all data collected were treated with strict confidentiality in accordance with applicable research ethics protocols.

The primary data collection instruments included a validated General Physics Achievement Test comprising multiple-choice questions and problem-solving items, and adapted observation checklists and questionnaires measuring engagement, motivation, and perceived effectiveness. Content validity of the achievement test was established through expert panel review, and the reliability of the adapted questionnaires was confirmed prior to administration.

Data collection followed the sequence of pretesting, implementation of the gamified intervention, posttesting, and data processing. The Scie-Quest platform incorporated gamification elements—including points, badges, leaderboards, simulations, and immediate feedback—to scaffold students' computational and problem-solving skills. Descriptive statistics, including mean, frequency, percentage, and standard deviation, were used to analyze engagement, motivation, and perceived effectiveness data. A paired-samples t-test was applied to assess the statistical significance of the difference between pretest and posttest scores.

IV. RESULTS AND DISCUSSION

Students' Pre-Test and Post-Test Performance

The students' pretest and posttest performance in using Scie-Quest Gamification for school year 2025–2026 is presented in Table 1. The results revealed a significant improvement in students' computational skills following the Scie-Quest Gamification intervention. The mean score increased from 19.81 in the pretest to 31.24 in the posttest, indicating that students progressed from partial understanding to higher mastery and improved problem-solving abilities.

Table 1. Pre-Test and Post-Test Performance in Computational Skills

Indicators	Mean	SD	Verbal Interpretation
Pre-Test	19.81	3.115	Moderate
Post-Test	31.24	4.676	High

Students who initially performed at the moderate level struggled with selecting appropriate solution methods and executing mathematical computations, while those at the higher level demonstrated stronger application and analytical skills. These findings suggest that gamification enhanced students' motivation, engagement, and understanding of physics concepts, leading to improved academic performance (Sailer & Homner, 2020; Plass, Homer, & Kinzer, 2020; Okariz et al., 2023; Ajlouni et al., 2025). Inferential analysis further confirmed that the improvement in performance was statistically significant.

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Involvement in Scie-Quest Gamification

Table 2 presents the involvement of the respondents in Scie-Quest Gamification in terms of engagement and motivation. The respondents demonstrated high levels of involvement in both dimensions. Engagement obtained an overall mean of 4.42, indicating that students felt actively involved, self-directed, and comfortable learning physics concepts through the gamified platform. Students particularly valued the opportunity to learn at their own pace and to study concepts in alignment with their preferred learning styles. These findings support previous studies demonstrating that gamification enhances behavioral, emotional, and cognitive engagement in science learning (Sailer & Homner, 2020; Gaurina, Alajbeg, & Weber, 2025; Ajlouni et al., 2025).

Table 2. Involvement of the Students in Scie-Quest Gamification

Indicators	Mean	SD	Verbal Interpretation
Engagement	4.42	0.502	High
Motivation	4.44	0.491	High
Overall	4.43	0.497	High

In terms of motivation, the respondents obtained an overall mean of 4.44, interpreted as High. Students reported that the gamified activities encouraged cooperation, social interaction, and active participation during physics lessons. The highest-rated indicator revealed that game-based activities stimulated collaboration among classmates, suggesting that social interaction and teamwork were key motivational factors. These findings align with studies emphasizing that gamification strengthens motivation through competition, rewards, and social connectedness (Deci & Ryan, 2020; Sailer & Homner, 2020; Gaurina, Alajbeg, & Weber, 2025).

Percieved Effectiveness

Table 3 presents the level of perceived effectiveness of Scie-Quest Gamification in terms of concentration and focus, goal clarity, feedback quality, and challenge level. The respondents generally agreed that Scie-Quest Gamification was effective in supporting their learning experience in physics. The overall mean of 4.24 indicated positive perceptions of the gamified platform across all four dimensions, suggesting that the gamified learning environment successfully promoted student engagement, attention, and active participation during physics lessons.

In terms of concentration and focus, the respondents obtained an overall mean of 4.08, interpreted as Agree. Students reported that the game design helped them sustain attention and remain focused on physics concepts throughout the lessons.

The findings indicate that interactive and immersive game-based activities reduced distractions and improved cognitive engagement during learning sessions. These results support the studies of Plass, Homer, and Kinzer (2020), Sailer and Homner (2020), and Gaurina, Alajbeg, and Weber (2025), which emphasized that gamified learning environments increase students' focus and attention through interactive and engaging instructional experiences.

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Table 3. Perceived Effectiveness of Scie-Quest Gamification

Indicators	Mean	SD	Verbal Interpretation
Concentration and Focus	4.08	0.297	Agree
Goal Clarity	4.49	0.669	Agree
Feedback Quality	4.27	0.653	Agree
Challenge Level	4.12	0.555	Agree
Overall	4.24	0.544	Agree

For goal clarity, the respondents obtained an overall mean of 4.49, interpreted as Agree. Students clearly understood the objectives, expectations, and success indicators within the gamified activities. The findings suggest that Scie-Quest provided structured guidance that enabled learners to remain focused on accomplishing learning tasks and understanding physics concepts. These results align with the findings of Sailer and Homner (2020), Plass, Homer, and Kinzer (2020), and Ajlouni et al. (2025), which highlighted that clearly defined goals and progress tracking systems enhance learning engagement and academic performance.

Regarding feedback quality, the respondents obtained an overall mean of 4.27, interpreted as Agree. Students perceived the immediate feedback and progress tracking features of Scie-Quest as helpful in correcting mistakes, monitoring performance, and improving understanding of physics concepts. The results indicate that feedback mechanisms encouraged continuous learning and strengthened students' motivation to complete activities. These findings support the studies of Plass, Homer, and Kinzer (2020), Sailer and Homner (2020), and Ajlouni et al. (2025), which emphasized that immediate feedback in gamified learning environments improves student engagement, motivation, and academic achievement.

In terms of challenge level, the respondents obtained an overall mean of 4.12, interpreted as Agree. Students perceived the gamified tasks as appropriately challenging and manageable, encouraging them to persevere in solving physics problems without feeling overwhelmed.

Although some respondents showed neutral perceptions regarding the gradual increase in task difficulty, the overall findings indicate that Scie-Quest maintained a balanced level of challenge that supported active participation and problem-solving. These findings are consistent with the studies of Sailer and Homner (2020) and Gaurina, Alajbeg, and Weber (2025), which found that properly balanced gamified challenges increase student motivation, persistence, and engagement in learning activities.

Significant Difference on Test Performances

Table 4 presents the results of the paired-samples t-test comparing the pretest and posttest scores of the respondents. The computed result, $t(62) = -20.0$, $p < .001$, revealed a highly significant difference between the two sets of scores. The null hypothesis was rejected, as the p-value remained well below the 0.05 significance level. These findings provide statistical evidence that the Scie-Quest Gamification intervention produced a genuine and meaningful improvement in students' computational skills.

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Table 4. Significant Difference on Pre-Test and Post-Test Performance on Computational Skills

	Statistic	df	p	Mean diff	SE diff	Cohen's d
Pre-Test	-20.0	62.0	<.001	-11.4	0.570	2.52
Post-Test						

Note. H_a μMeasure 1 - Measure 2 ≠ 0

The mean difference of −11.4 confirmed that posttest scores were substantially higher than pretest scores, while the standard error of 0.570 indicated a high degree of consistency in students' improvement across the sample. Furthermore, Cohen's d was computed at 2.52, signifying a very large practical effect size (Cohen, 1988). This result indicates that the observed gains are not only statistically significant but also of substantial educational importance, underscoring the meaningful impact of the intervention on students' computational performance.

The negative t-statistic confirmed that posttest results exceeded pretest results, demonstrating that the observed gains reflected actual progress rather than chance variation. The structured game-based computational tasks required students to apply formulas, analyze data, and select appropriate solution strategies within the gamified platform. Through this process, students developed step-by-step problem-solving skills and logical reasoning abilities, reinforced by the platform's immediate feedback mechanisms.

These results support recent findings demonstrating that interactive, gamification-based teaching approaches lead to improved student outcomes in computational thinking, critical thinking, and academic achievement. Alqarni (2025) found that gamification improved students' abilities in computational thinking and visual programming. Similarly, Gómez Niño et al. (2024) reported that gamified learning environments enhanced critical thinking and essential 21st-century competencies through heightened engagement and increased cognitive processing.

V. CONCLUSION

The study concluded that Scie-Quest Gamification effectively improved the computational skills, engagement, and motivation of Grade 12 STEM students in General Physics II at Atimonan National Comprehensive High School.

The significant improvement between the respondents' pretest and posttest scores, supported by a very large effect size (Cohen's d = 2.52), demonstrated that the gamified learning approach enhanced students' understanding and application of physics concepts, particularly in electromagnetic waves and optics.

The respondents also demonstrated high levels of engagement and motivation, actively participating in learning activities, collaborating with classmates, and sustaining interest throughout the intervention. Furthermore, students positively perceived Scie-Quest Gamification in terms of concentration and focus, goal clarity, feedback quality, and challenge level, indicating that the platform provided an engaging, structured, and supportive learning environment that contributed to improved academic performance and learning outcomes.

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Limitations

Several limitations of this study should be acknowledged. First, the pre-experimental one-group pretest-posttest design does not include a control group, which limits the ability to establish a strict causal relationship between the intervention and the observed improvements. Factors such as the history effect (external events occurring concurrently during the four-week intervention), maturation (natural academic development over time), and the testing effect (familiarity with test content following pretest exposure) may have partially contributed to the observed gains and cannot be entirely ruled out. Second, the use of convenience sampling from two intact sections at a single school limits the generalizability of the findings to other contexts, schools, or student populations. Third, the study was confined to electromagnetic waves and optics topics within General Physics II, and the results may not transfer to other physics topics or subject areas. Future researchers are encouraged to address these limitations through more rigorous experimental designs.

Recommendations

Based on the findings and limitations of this study, the following recommendations are offered. For physics educators, the adoption of gamification platforms such as Scie-Quest is encouraged as a supplementary instructional tool to enhance student engagement, motivation, and computational performance, particularly in abstract and mathematically intensive topics. For school administrators, sustained support for the integration of technology-based learning platforms into the curriculum is recommended, including the provision of adequate devices and reliable internet connectivity. For future researchers, it is recommended that subsequent studies employ a quasi-experimental or true experimental design with an equivalent control group to strengthen causal inferences. Additionally, longer intervention periods, broader subject areas, and larger and more diverse samples would contribute to a more comprehensive and generalizable understanding of the effects of gamification in Philippine senior high school science education.

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